

OTTV ANALYSIS FOR ENERGY EFFICIENCY IN MAHLIGA COFFEE SLEMAN YOGAYAKARTA

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ABSTRACT: Energy efficiency is an essential goal for commercial businesses, especially in the coffee shop industry, in their efforts to achieve sustainable architecture. Indonesia as well as other nations have implemented Overall Thermal Transfer Value (OTTV) regulations to ensure that buildings are designed to minimize the amount of external heat they absorb. This helps to reduce the energy needed for cooling. According to the Standard Nasional Indonesia (SNI) 6389: 2011, the OTTV value should not above 35 watts/m² as per the standard. This study will utilize Mahliga Coffee, one of the cafes in Sleman Regency, Special Region of Yogyakarta, as a case study. The goal of this study is to determine the amount of OTTV value produced and identify the design variables that impact it, so enhancing the energy efficiency of the structure. This study methodology uses quantitative research methodologies by manipulating design variables such as Windows to Wall Ratio (WWR), U value and Material. The building's overall Overall Thermal Transfer Value (OTTV) is 56.88 W/m², slightly above the standard. By reducing the Window-to-Wall Ratio (WWR) on the East side to 14.84%, the Overall Thermal Transfer Value (OTTV) of the building was effectively decreased to 34.23 W/m².

Keywords: energy efficiency, mahliga coffee, ottv calculation U value, Windows to Wall Ratio (WWR)

INTRODUCTION

Background

The global growth of the coffee shop industry has surely led to increased energy consumption and resource utilization. From the electricity needed to power espresso machines and lights to the coffee itself, coffee shops play a significant role in energy demand. Additionally, the industry generates waste, including packaging materials and coffee grounds. As we strive for sustainable practices, it becomes crucial to address energy efficiency in coffee shop establishments.

In some countries, such as Indonesia, energy efficiency standards are implemented to minimize external heat gains in buildings. One such standard is the Overall Thermal Transfer Value (OTTV), which ensures that structures are designed to reduce the energy required for cooling. According to the Indonesian Standard Nasional Indonesia (SNI) 6389:2011, the OTTV value must not exceed 35 watts/m².

Whereas OTTV has been examined in several applications, there is a lack of study that focuses specifically on coffee shops, especially in Indonesia. Sukri et al. (2022) conducted an energy audit on a coffee shop in Malaysia, focusing on overall energy consumption patterns but not specifically on OTTV. In a related study, Kristanto and Juniwati (2018) examined the energy performance of cafés in Jakarta, Indonesia, but their focus was primarily on lighting and air conditioning systems rather than building envelope performance.

This research study case on Mahliga Coffee, a café located in Sleman Regency, Special Region of Yogyakarta, Indonesia. As a commercial building with a modern design that extensively uses glass openings, Mahliga Coffee is interesting to study regarding its potential for improving energy efficiency through OTTV analysis. By analyzing the OTTV value produced by Mahliga Coffee and investigating design variables that influence it, we aim to enhance the

energy efficiency of the building. The goal of study is recommendations for energy efficiency improvements in the context of Indonesia's rapidly growing coffee shop industry.

The research methodology employs quantitative methods, specifically modifying design variables related to the Windows to Wall Ratio (WWR), U value and Material. This methodology provides valuable insights into the application of OTTV analysis in the context of small-scale commercial buildings. These buildings, are frequently overlooked in energy efficiency studies, although increasing in number and collectively contributing to urban energy consumption.

Research Question:

1. How much OTTV value is produced?
2. What design variables influence it which can boost the energy efficiency on the building?
3. How does the window to wall ratio (WWR) affect the thermal performance?

LITERATURE REVIEW

1. Sustainable Architecture and Energy Efficiency

Sustainable architecture is crucial in the effort to create buildings that are energy-efficient. As the continuing development of the worldwide coffee shop sector, it becomes essential to deal with the issue of energy consumption. Sustainable design principles aim to reduce environmental impact while ensuring the comfort of occupants. Researchers highlight the need of using measures like passive solar design, natural ventilation, and efficient lighting systems to improve energy efficiency in businesses. Integrating sustainable practices becomes essential to coffee shops, which operate in energy-intensive places of business.

2. Overall Thermal Transfer Value (OTTV)

The Overall Thermal Transfer Value (OTTV) assesses a building's heat gain potential due to solar radiation. According to SNI 6389:2011, which limits OTTV to 35 watts/m², ensures energy-efficient coffee shop designs. It considers window orientation, shading devices, and glazing properties. The formula for OTTV is:

$$\text{OTTV}_i = 15\alpha [1 - \text{WWR}) U_w + 5(\text{WWR}) U_f + (194 \times \text{CF} \times \text{WWR} \times \text{SC}) \quad (1)$$

WWR : Window-to-Wall Ratio

U_w : The wall's U value

U_f : The glass' U value

SC : Shading Coefficient

3. Windows to Wall Ratio (WWR) and U Value

3.1 Windows to Wall Ratio (WWR)

The Windows to Wall Ratio (WWR) significantly influences energy performance. It represents the proportion of window area relative to the total wall area in a building. A higher WWR allows more natural light, reducing the need for artificial lighting during daylight hours. However, excessive glazing can lead to increased heat gain or loss. Researchers have explored optimal WWR values for different climates and building types . Balancing aesthetics, daylighting, and energy efficiency is crucial in coffee shop designs. The formula for WWR is:

$$\text{WWR} (\%) = \frac{\sum \text{Glazing area (m}^2\text{)}}{\sum \text{Gross exterior wall area (m}^2\text{)}}$$

3.2 U Value

The U value (heat transfer coefficient) quantifies heat exchange through a building envelope. A lower U value indicates better insulation. Proper material selection and insulation techniques are essential to achieve optimal U values . In coffee shop design,

windows and walls significantly impact the overall U value. Strategic insulation and glazing choices contribute to energy efficiency and occupant comfort.

4. Shading Coefficient

The shading coefficient is an amount that indicates the capacity of a glazing system, such as windows or glass, to obstruct the entry of solar heat. It measures the amount of solar heat that passes through the glazing material in relation to normal clear glass. On the other hand, a shading device covers any component or device integrated into the outer or inner parts of a structure to regulate the quantity of sunlight and solar heat that penetrates the building, such as projections, canopies, slats, window coverings, and screens. Strategically employing shading devices can effectively decrease the amount of solar heat that enters through windows or glazed surfaces.

METHOD

The research located at the Mahliga Coffee building located in Tj. Sari, Umbulmartani, District. Ngemplak, Sleman Regency, Special Region of Yogyakarta. The building is a modern café that provides co-working space for visitors. This research was conducted from April 2024 to June 2024. The method that will be quantitatively used in this study is OTTV calculation which will be done in three stages. The stages of data collection were carried out:

1. Observation Stage

Observation stage, carried out by visiting the location to be able to know the actual existing conditions so that they can be identified clearly and in detail.

2. Data Evaluation Stage

From existing data will be able to make possible designs and modifications that might be produced. This modification consists of WWR, U Value, and Material. All of the calculations will be done by utilizing the OTTV Calculator spreadsheet by government the Republic of Indonesia.

3. Data analysis stage

Analysis is carried out based on the evaluation results with three results from three modifications in total. If the performance results do not meet the standards, it will provide the best recommendations that can be selected to be developed into a comprehensive design strategy that can be implemented for coffee shops in the future.

Existing Data

Mahliga Coffee offers a comfortable and aesthetically pleasing environment for coffee enthusiasts. Located at Tj. Sari, Umbulmartani, Kec. Ngemplak, Kabupaten Sleman, Daerah Istimewa Yogyakarta. This café is known for its spacious indoor and outdoor seating areas, making it an ideal spot for working, studying, or hang out with friends.

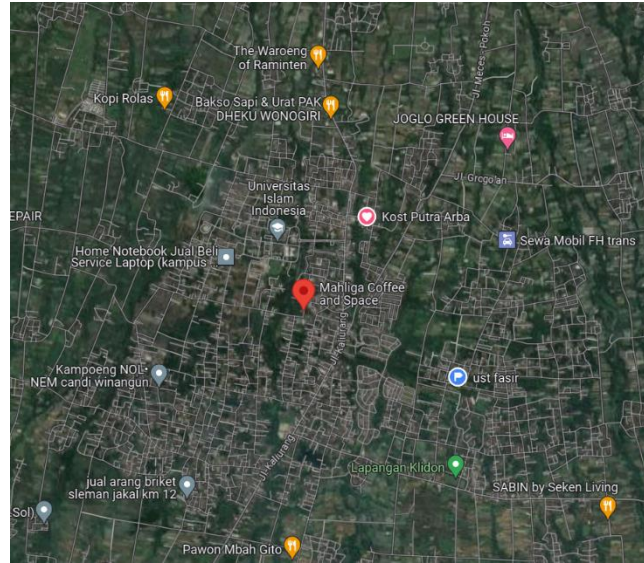


Figure 1 Location map of Mahliga Coffee
 Source: Google Maps, 2024



Figure 2 The front view of Mahliga Coffee
 Source: Author, 2024

The research procedure begins by examining the fundamental aspects of building size and area. The calculation of WWR and OTTV values is not possible without considering these dimensions. The data was obtained from the building's technical drawing, but cannot be shared in the study due to privacy concerns.

Table 1 Building Dimensions

Elevation	Length (m)	Height (m)	Total Area (sqm)
West	13	2.8	36.4
East	13	2.8	36.4
North	10	2.8	28
South	10	2.8	28

Source: Author, 2024

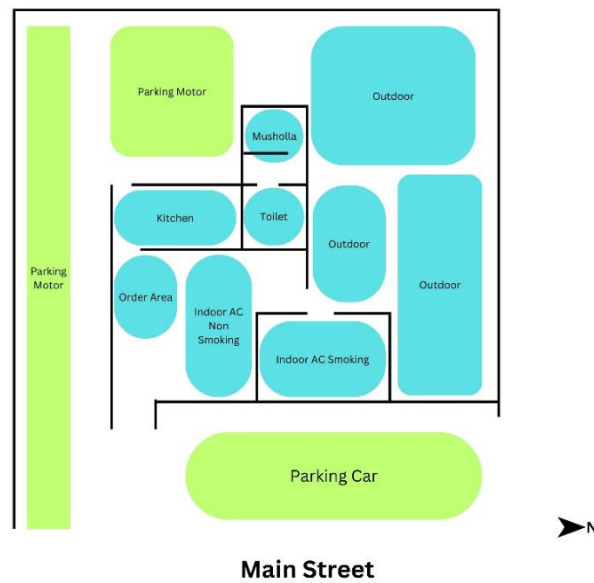


Figure 3 Schematic Site Plan of Mahliga Coffee
Source: Author, 2024

The next phase is determining the current state of the building, including its dimensions, area, and the quantity and type of openings. The building's technical drawings and a direct survey have been used to identify 25 types of openings, as stated in the table below.

Table 2 Opening Types

Opening Type	Opening Name	Opening Size (m)	Total Opening Area (sqm)	Fenestration Type	Location(s)
Window	W1	1,2 x 1	1.2	F1	East
	W2	1,2 x 1	1.2	F1	East
	W3	1,2 x 1	1.2	F1	East
	W4	1,2 x 1,8	2.16	F2	East
	W5	1,2 x 1,8	2.16	F2	East
	W6	1,2 x 1,8	2.16	F2	East
	W7	1,2 x 0,8	0.96	F2	West
	W8	1,2 x 0,8	0.96	F2	West
	W9	1,2 x 2	2.4	F2	West
	W10	1,2 x 2	2.4	F2	West
	W11	1,2 x 1,3	1.56	F2	West
	W12	1,2 x 1	1.2	F1	East
	W13	1,2 x 1	1.2	F1	East
	W14	1,2 x 1	1.2	F1	East
	W15	1,2 x 1	1.2	F1	East
	W16	1,2 x 1,8	2.16	F2	East
	W17	1,2 x 1,8	2.16	F2	East
	W18	1,2 x 1,8	2.16	F2	East
	W19	1,2 x 1,8	2.16	F2	East
	W20	1 x 1	1	F2	North
	W21	1 x 1	1	F2	North
Door	D1	0,8 x 0,8	0.64	F3	East
	D2	0,8 x 0,7	0.56	F4	East
	D3	0,8 x 2	1.6	F3	North
	D4	0,8 x 2	1.6	F3	West

Source: Author, 2024

Based on both technical drawings and actual surveys, it can be determined that the glass material or kind of fenestration for each aperture may vary. The following are the four types of fenestrations that can be found, along with their respective Solar Heat Gain Coefficient (SHGC), U Value, and the presence of a shading device.



Figure 4 Glass Windows Inside of Mahliga Coffee
Source: Author, 2024

Table 3 Fenestration Types

Fenestration Type	Name	SHGC	U Value	Shading
F1	Glass Clear 6mm	0.67	0.41	No
F2	Glass Clear 6mm	0.67	0.41	Yes
F3	Glass Clear 8mm	0.93	0.41	No
F4	Glass Clear 8mm	0.93	0.41	Yes

Source: Author, 2024

RESULT

1. WWR Results

The Window-to-Wall Ratio (WWR) of the building was calculated by dividing the total dimension of the building's facade by the combined area of all the openings in the facade. The table displays the percentage of space used by the opening. The results show that the East elevation still has the highest WWR at 62.97%, while the South elevation remains without windows, resulting in a WWR of 0%.

Table 4 WWR Results

Elevation	Wall Area (m ²)	Window Area (m ²)	WWR (%)
North	28	2	7.14
South	28	0	0
West	36.4	8.28	22.75
East	36.4	22.92	62.97

Source: Author, 2024

2. OTTV Results

The overall OTTV for the building Mahliga Cofffe is now 56.88 W/m², which is higher than the standard value of 35 W/m² as per SNI 6389:2011. The Overall Thermal Transfer Value (OTTV) was calcaulted using the OTTV Calculator spreadsheet :

Table 5 OTTV Results

Elevation	North	South	West	East
Wall Conduction	251.20	607.07	609.68	352.82
Opening Conduction	18.08	-	74.85	75.18
Opening Heat Conduction	270.00	-	1,324.80	3,742.62
Total	539.28	607.07	2,009.33	4,170.62
Total Facad Area	28.00	28.00	36.40	36.40
OTTV	19.26	21.68	55.20	114.58
Total	56.88			

Source: Author, 2024

DISCUSSION

Based on the results, we can identify several design factors that influence the OTTV and potential areas for improvement:

1. WWR

The East elevation shows a significantly higher Window-to-Wall Ratio (WWR) in comparison to the other elevations. The WWR (62.97%) is responsible for the increased overall thermal transfer value (OTTV) for the East elevation, exceeding the standard limit. Reducing the WWR on the East elevation might be useful in reducing the OTTV. According to Purwoko & Purwanto (2022), WWR has a substantial influence on the energy efficiency of buildings. However, they advise that an overly aggressive decrease in the window-to-wall ratio (WWR) can result in higher lighting demands, therefore necessitating a careful balance. Focus on the east side only, the lower window openings can be replaced with regular walls as they provide too much exposure to the room and the east side tends to get the maximum amount of heat during the day.

Table 6 WWR Modification

Elevation	East
Modifications	Removing window area
Type of windows	Removing 7 of F2 (W4, W5, W6, W16, W17, W18, W19) and Removing 2 of F1 (W1, W2)
Previous Opening Area (sqm)	22.92
Modified Opening Area (sqm)	5.4
Previous WWR (%)	62.97
Modified WWR (%)	14.84
Previous OTTV	56.88
Total OTTV after modified	34.23

Source: Author, 2024

The result show Total OTTV after modified 34.23 W/m², it means it can be successfully standard requirements below 35 W/m².

2. Glass Material

An further option for enhancing the OTTV is to change the transparent material, such as glass. The current use of clear glass (6mm and 8mm) with high SHGC values (0.67 and 0.93) contributes to increased solar heat gain. Replacing these with high-performance glazing options could significantly reduce the OTTV.

In this situation, any aperture utilizing clear glass 8 mm will be changed with alternative transparent glass materials containing reduced Solar Heat Gain Coefficient (SHGC) or U Value. This strategic change has the goal to enhance the thermal performance of the building and, as a result, improve its overall energy efficiency.

Table 7 Glass Material Modification

Glass Material	SHGC	U Value	OTTV
Glass Clear 8mm	0.67	0.41	56.88
Triple Glazing with Argon Fill and Low-E Coating	0.20	0.8	49.93
Electrochromic glass	0.15	1.1	43.14

Source: Author, 2024

Although being replaced the material is **49.93** and **43.14** W/m², but still maintains a high level of quality and above the overall OTTV standard 35 W/m².

3. Shading Devices

Although certain windows are equipped with shade systems, not all windows have this feature. Adding external shading devices, particularly on the East and West elevations, could help reduce solar heat gain and lower the OTTV. The AMC study showed that implementing an eggcrate shading device could improve OTTV by 16.4% (Arkan et al., 2023). In addition, the design of the structure may include shading devices. Reducing solar heat gain is the goal of this technique, especially at elevations with high Window-to-Wall Ratios (WWR). Let's look at the SHGC reduction that various shading devices can offer in order to comprehend their effects. The shading devices provide an average SHGC reduction of 0.2.

Table 8 Shading Device Modification

Elevation	OTTV Before	Reduction (%)	OTTV After Modified
North	19.26	24.7	14.50
South	21.68	24.7	16.33
West	55.20	24.7	41.57
East	114.58	24.7	86.31
Total OTTV	39.68		

Source: Author, 2024

The result of adding shading devices is 39.68 W/m², but still maintains a high level of quality and above the overall OTTV standard 35 W/m².

CONCLUSION

This study focused on analyzing the Overall Thermal Transfer Value (OTTV) of Mahliga Coffee in Sleman Regency, Special Region of Yogyakarta. The goal was to evaluate its energy efficiency and make recommendations for improvement. The building's initial OTTV value was determined to be 56.88 W/m², which exceeds the standard is 35 W/m² set by the Indonesian Standard Nasional Indonesia (SNI) 6389:2011. This recommendation can be important opportunity to improve energy efficiency by making specific design changes.

In summary, the analysis shows that modifying the Window-to-Wall Ratio (WWR) on the East elevation from 62.97% to 14.84% is the most efficient approach to enhance the building's energy efficiency. By making this change, the Overall Thermal Transfer Value (OTTV) is reduced to 34.23 W/m², which meets the limit of 35 W/m² set by the Indonesian Standard Nasional Indonesia (SNI) 6389:2011. Although changed material glass and additional shading devices have an essential part in reducing the OTTV, they just do not meet the requirements of the SNI standard. Therefore, reducing the Window-to-Wall Ratio (WWR) appears to the optimal strategy to ensuring that the building's energy efficiency is in alignment with the national standards specifically on SNI about OTTV.

Notes for future research, this study was recommendation that reducing the WWR is effective in producing a small OTTV. However, since with the WWR now just only 14.84%, there comes out a major questions regarding the affect of smaller windows on daylighting. The future research should into this area to find out whether the reduced window size affects the natural lighting inside the building. It's crucial for finding balance between minimizing heat gain and ensuring sufficient daylight. This involves finding the best placements for windows and implementing daylighting strategies as light shelving. These components will help in keeping energy efficiency without losing occupant productivity or comfort because of insufficient natural light.

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